Before The
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In The Matter Of	)	
Establishment of an Interference Temperature Metric to Quantify and Manage Interference and to Expand Available Unlicensed Operation in Certain Fixed, Mobile, and Satellite Frequency Bands	)	ET Docket No. 03-237

To: The Commission

COMMENTS OF QUALCOMM INCORPORATED

Klein Gilhousen
Samir Soliman
Steven Morley
Onkar Dabeer
QUALCOMM Incorporated
5775 Morehouse Drive
San Diego, CA 92121

Dean R. Brenner
Senior Director, Government Affairs
QUALCOMM Incorporated
2001 Pennsylvania Ave., N.W.
Suite 650
Washington, D.C. 20006
(202) 263-0020
Attorney for QUALCOMM Incorporated

Dated: April 5, 2004

SUMMARY

QUALCOMM applauds the FCC for attempting to encourage the efficient use of spectrum, a precious national resource. QUALCOMM, one of the world's leaders in developing new digital communications technologies, has itself been devoted from its inception to inventing technologies to enable digital communications networks to operate at the most spectrally efficient level. QUALCOMM certainly agrees that the Commission should adopt policies that reward spectral efficiency, both in licensed and unlicensed bands. The proposed interference temperature metric, with further study and refinement, may be useful in unlicensed bands where there are not strong incentives for efficient use due to the shared nature of the bands and where additional unlicensed operations would be compatible with the existing uses of the bands.

However, QUALCOMM does not support the imposition of the new interference metric, which is designed to enable greater unlicensed operations, in licensed bands. QUALCOMM shows herein that even what the Commission considers a slight increase in the noise temperature in a licensed band would substantially impair the service provided by licensees who have deployed Code Division Multiple Access ("CDMA") technology, resulting in a substantially reduced coverage area of each cell and a decreased battery life in each wireless phone.

The carriers who have deployed CDMA in the United States have collectively spent tens of billions of dollars to deliver very high quality wireless service. As the company that developed the core technical properties of CDMA, QUALCOMM is uniquely situated to quantify the impact on CDMA networks if the FCC were to apply the new metric to the licensed bands on which these networks operate. QUALCOMM has found that increasing the noise temperature in the PCS, cellular, or other licensed bands would substantially degrade the quality

of service. Such a result would be entirely contrary to the public interest. The FCC should not permit the noise level to be raised in licensed bands, especially the cellular and PCS bands.

In the UWB and 700 MHz proceedings, the FCC ruled that a 1 dB increase in noise does not constitute harmful interference. If the FCC were to permit a 1 dB increase in noise temperature through the interference temperature metric, an increase that the FCC apparently deems tolerable, each CDMA cell would suffer a 10-15% decrease in its coverage area. Conversely, for a licensee to maintain its present coverage area in the face of a 1 dB increase in noise temperature, it would have to increase its present number of cell sites by approximately 12-17%, an impossible task in light of the zoning and practical difficulties that carriers face to add cell sites and, even if possible, a very expensive undertaking.

Further, such an increase in noise temperature would decrease the battery life of a CDMA wireless phone by over 20% as the phone would need to use additional power to overcome the unlicensed noise. This would reverse years of technological progress which has enabled the production of wireless phones with ever-increasing battery lives.

QUALCOMM believes that the Commission should not use the interference temperature metric in any licensed band for which CDMA technology has been or is likely to be deployed, including 800 MHz, 1.9 GHz, the advanced wireless bands (1.7/2.1 GHz), 700 MHz, 2500-2690 MHz (MMDS), the MSS/ATC bands (S, L, and Big Leo), and 2.3 GHz (WCS), as well as the Ku and Ka-Bands, and the bands identified in the NPRM, the 6.525-6.7 and 12.75-13.25 GHz bands.

While this is an important commercial and quality of life issue, it is also a significant public safety issue. Pursuant to the FCC's E911 mandate, tens of millions of Americans now own wireless phones with Assisted GPS technology to enable 911 call centers to locate the callers with a high degree of precision. Assisted GPS technology depends on an unimpaired PCS or cellular link, as well as an interference-free GPS signal, to transmit the call and the location information to the 911 center. QUALCOMM showed in a prior study filed with the FCC that an increase in the noise temperature decreases the availability of GPS satellites to wireless phones using Assisted GPS, decreasing the accuracy of the location information provided by the phone.

This technology can save lives. There is no reason to jeopardize this technology, which was not designed to operate in the face of greater noise from unlicensed devices operating on top of or underneath PCS, cellular, and GPS services in their bands. This could occur if the FCC imposes the interference temperature metric in the PCS, cellular, or GPS bands.

There is also another reason why it would be unfair and unnecessary to apply the new metric to the PCS and cellular bands: CDMA networks inherently operate at the efficient level of spectrum and power. There is no basis for the FCC to take any action in the name of increasing the efficiency of CDMA networks, whose operators should not face new burdens.

The power control inherent in CDMA networks and mobiles ensures that each mobile always transmits exactly enough power to provide decent call quality, but not more than enough. For example, on the return link, CDMA base stations constantly measure the error rate performance from each mobile transmitting a signal, and, depending on whether the error rate is trending above or below an adequate performance level, the power control circuit is told to ask for a higher or lower signal to noise ratio. A base station function measures the actual signal to noise ratio and compares it to the target, and if the actual ratio is too high or too low, an "up power" or "down power" command is sent to the mobile, which responds by increasing or decreasing its power by approximately 1 dB. All of this occurs approximately 1,000 times per second at each base station and for each operating mobile. The mobile continuously measures the received signal level of the base station signal, averaged over a relatively long time interval, but with a very large dynamic range (about 80 dB). These measurements are used to set the mobile transmit power at approximately the optimal level over this very large dynamic range. The base station commands have a much smaller range, but are transmitted much faster.

CDMA mobiles also have variable rate vocoders that vary the data rate over an 8 to 1 range since lower power can be used for lower data rates. This permits the mobile to adjust the power on a frame by frame basis (20 milliseconds) based on the varying data rate.

For soft handoff between base stations, the relative strength of nearby base stations is continuously monitored. Although all base stations communicating with a mobile try to control its power, it pays attention only to the one asking for the lowest power. CDMA uses powerful forward error correction coding and efficient modulation and implementation so that the signal to noise ratios are very low- approaching Shannon limits. All these features ensure that CDMA networks and mobiles operate at the most efficient levels, and there is no reason to apply a new interference metric on the bands at which CDMA networks and mobiles operate.

The NOI/NPRM theorizes a sophisticated real time, nationwide monitoring and communications system across multiple networks to implement the interference temperature metric which does not exist today. QUALCOMM does not believe that it is practical to believe that there will ever be such a system on the PCS, cellular, MMDS, advanced wireless services, MMDS, and 700 MHz bands. Conceptually, an unlicensed transmitter cannot possibly know the interference it will cause at all licensed receivers before it transmits since it would have to know both the noise temperature of the licensed receivers and the gain that each licensed receiver has in the direction of the unlicensed transmitter. As a result, the unlicensed transmitter would begin to transmit and interfere before each licensed transmitter had sent it information about the interference. However, because some licensed transmitters would already be suffering from interference, there is no guarantee that the messages would reach the unlicensed transmitter.

With regard to the bands covered by the NPRM portion of the Commission's proposal, 6525-6700 MHz and 12.75-13.25 GHz, QUALCOMM believes that any such monitoring system would be unduly complicated, expensive, and vulnerable to intentional and unintentional failures. Indeed, QUALCOMM does not believe that an increase in interference temperature as posited by the Commission to foster greater can be implemented in the foregoing bands, or any other licensed bands, without causing harmful interference. Thus, the Commission should not impose the new metric in any licensed band.

TABLE OF CONTENTS

Before The
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In The Matter Of	)	
Establishment of an Interference Temperature Metric to Quantify and Manage Interference and to Expand Available Unlicensed Operation in Certain Fixed, Mobile, and Satellite Frequency Bands	)	ET Docket No. 03-237

To: The Commission

COMMENTS OF QUALCOMM INCORPORATED

QUALCOMM Incorporated ("QUALCOMM") hereby submits its Comments in the above-captioned proceeding. As set forth in the Summary, supra, while QUALCOMM applauds the Commission for seeking to promote spectral efficiency and proposing the interference temperature metric, which could be quite useful in unlicensed bands, where there are no incentives for efficient operation and where additional unlicensed operations would be compatible with the existing uses of the bands, QUALCOMM does not believe that the Commission should impose the new metric in licensed bands. In particular, QUALCOMM shows that the public interest would suffer if the Commission were to apply the new metric in any band on which a CDMA-based network now operates or could operate in the future.

I. Background

QUALCOMM is a world leader in developing innovative digital wireless communications technologies and enabling products and services based on the digital wireless communications technologies that it develops. QUALCOMM has developed core technology known as code division multiple access ("CDMA"). This technology has been incorporated into standardized wireless technologies deployed by wireless carriers in the United States and around the world, including cdmaOne, the second generation (2G) version of CDMA, and CDMA2000, the third generation (3G) version of CDMA. Taken as a whole, CDMA is America's fastest growing digital communications technology. Due to its unsurpassed voice quality, data delivery speeds and performance, system capacity, spectral efficiency, privacy, and inherent flexibility, virtually all third generation ("3G") wireless products and services are based on CDMA.

The 3G CDMA technologies include CDMA2000, which operates on 1.25 MHz channels, WCDMA (also known as wideband CDMA or UMTS), which operates on 5 MHz channels, and TD-SCDMA, which is a TDD-based CDMA technology. CDMA2000 includes both 1xRTT and 1xEV-DO, both of which enable carriers to provide advanced 3G services in a narrow swath of spectrum.

CDMA networks operate today in the United States on licensed PCS and cellular spectrum in the 800 MHz and 1.9 GHz bands, and carriers have collectively spent tens of billions of dollars on these networks. In addition, it is likely that versions of CDMA will be deployed in terrestrial networks operating at the 700 MHz, 2500-2690 MHz , 1.7/2.1, and MSS/ATC bands (S Band, L Band, and Big Leo Band). CDMA has been deployed in satellite-based networks in the Ku-Band and the Big Leo Band, and could well be deployed in the Ka-Band.

CDMA is proliferating at a rapid pace, here in the United States and around the world. As of Februrary 2004, there were 188 million CDMA subscribers worldwide. 3G CDMA has been deployed by a total of 75 carriers, which are based in the United States and 36 other countries around the world. A total of 48 of those operators have reported that they already have a total of over 94 million subscribers for 3G CDMA services. Operators in the United States and elsewhere around the world who have deployed 3G CDMA have experienced dramatic and rapid growth in both in terms of numbers of subscribers and average revenue per subscriber.[1]

The products and services based on 3G CDMA enable wireless data to be sent and received at very high speeds: the first release of 1xRTT technology, which has been deployed here in the United States by Sprint PCS, Verizon Wireless, ALLTEL, US Cellular, and other carriers, enables data to be sent and received wirelessly at peak rates of 144 kbps, and the first release of 1xEV-DO technology, which has been deployed by Verizon Wireless initially in Washington, DC and San Diego and will be deployed throughout the country by the end of 2005, and by other carriers around the world in countries such as South Korea, Japan, and Brazil, enables data to be received wirelessly at multi-megabit peak rates and average rates of hundreds of kilobits per second, speeds that are comparable to wireline broadband technologies such as cable modems and DSL. In addition, carriers in Japan, Europe and elsewhere have deployed WCDMA/UMTS-based networks, which deliver data at peak rates of 384 kilobits per second and can be upgraded to HSDPA, which delivers multi-megabit peak rates. This WCDMA/UMTS technology will be deployed soon in the United States. In sum, 3G CDMA, in all of its flavors, enables subscribers to enjoy high speed wireless data service.

Moreover, QUALCOMM broadly licenses CDMA technology to over 100 leading handset and infrastructure equipment manufacturers around the world. At present, there are 46 vendors who have manufactured 458 different 3G device models that are now commercially available in the United States and elsewhere around the world. These devices include a wide array of wireless phones, PCMCIA cards, PDAs, and the like.

---

[1] Additional information about the proliferation of 3G CDMA services is available at www.3gtoday.com.

II. Increasing the Noise Temperature in Licensed Bands At Which CDMA Has Been or Will Likely Be Deployed Would Cause Substantial Harm to the Networks and to the Millions of Americans Who Depend on The Networks

Since the Commission began exploring proposals to allow greater operation of unlicensed devices in licensed bands several years ago, QUALCOMM has studied the possible interference to CDMA networks that could ensue. As QUALCOMM demonstrates below, even what the Commission considers to be a relatively small increase in the noise temperature would drastically curtail the coverage of a CDMA network. This would leave millions of Americans without the high quality wireless service on which they rely. There is no remedy to prevent this harm. Carriers would need to add large numbers of base stations just to replicate their present coverage area, at a cost of billions of dollars. However, due to zoning issues, site availability, and a host of other practical issues, it is doubtful that the carriers, even if they had the funds, could actually deploy these new base stations. As a result, the American public would suffer a substantial diminution of wireless service.

QUALCOMM has no doubt that the Commission would not wish to bring about such a bad outcome for the American public. For this reason, QUALCOMM asks the Commission to make clear that it will not impose the new interference temperature metric in any licensed band, but particularly in any band in which CDMA has been or is likely to be deployed.

A. Effect of Interference Temperature on CDMA Mobile Terminals

We consider the effects of increase in interference temperature on the forward link (FL) of CDMA Mobile Terminals (MTs). A CDMA FL is designed by considering the thermal noise floor N and the loading of the adjacent cells. Consider a MT at the cell edge and suppose the number of MTs in its adjacent cell is K. Suppose S is the signal power received by a MT at the cell edge. The FL cell layout is such that

$$\frac{S}{\nu KS + N} = SNR_o \tag{1}$$

where ν is a factor accounting for voice activity and the distribution of MTs in the adjacent cell, and, SNR_0 is chosen to meet the desired quality of service. Any increase in the thermal noise floor N reduces the received signal-to-noise ratio, and consequently reduces the E_b/N_o by the same amount, leading to decreased service area. We next derive the reduction in the cell radius.

Let I be the interference whose effect we wish to study. The increase in the thermal noise floor by the interference is

$$\Delta = \frac{I + N}{N}. \tag{2}$$

Due to increase in the noise temperature, more signal power is needed to compensate for the increase in noise temperature and to meet the minimum signal-to-noise ratio requirements. At the cell edge, the propagation loss is maximum, and the base station (BS) transmit power is maxed out. Hence it is not possible to increase the power transmitted by the BS to the MT and consequently the cell radius decreases. Suppose the decrease in cell radius increases the received signal strength of a MT at the cell edge by a factor □. Since we want to maintain the same E_b/N_o requirement, we need

$$\frac{S}{\nu KS + N} = \frac{\alpha S}{\nu K(\alpha S) + I + N}, \text{ which implies } \alpha = \Delta. \tag{3}$$

Thus the required increase in received signal power at the cell edge is equal to the increase in the noise temperature caused by the additional interference.

If the propagation loss exponent is denoted by □, then the percentage reduction in cell radius required is

$$\Delta r = 100\left(1-\left(\Delta^{(-1/\gamma)}\right)\right). \qquad (4)$$

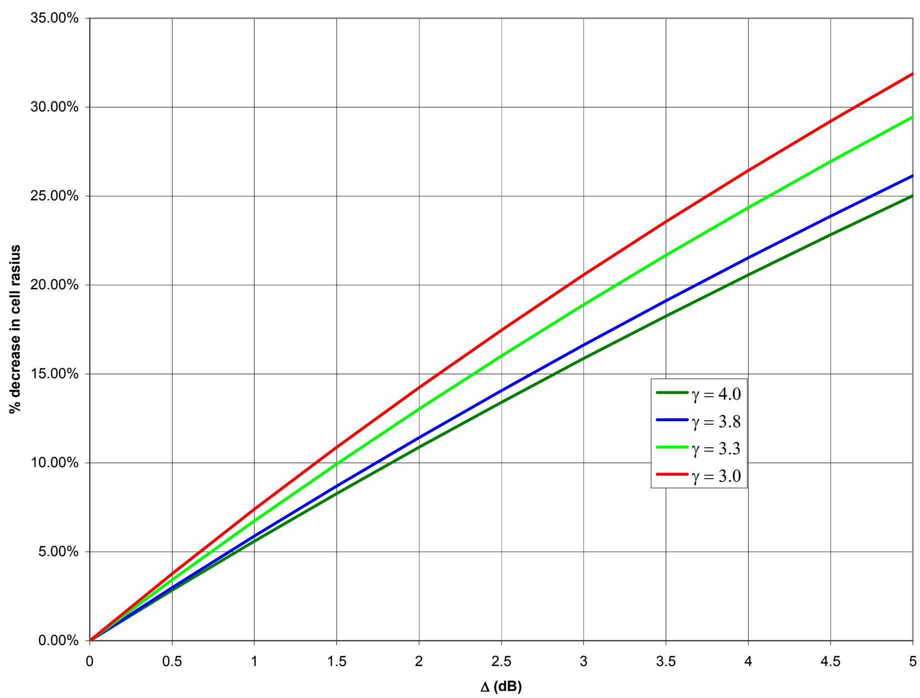

Figure 1: Reduction in cell radius due to □ increase in *noise temperature.*

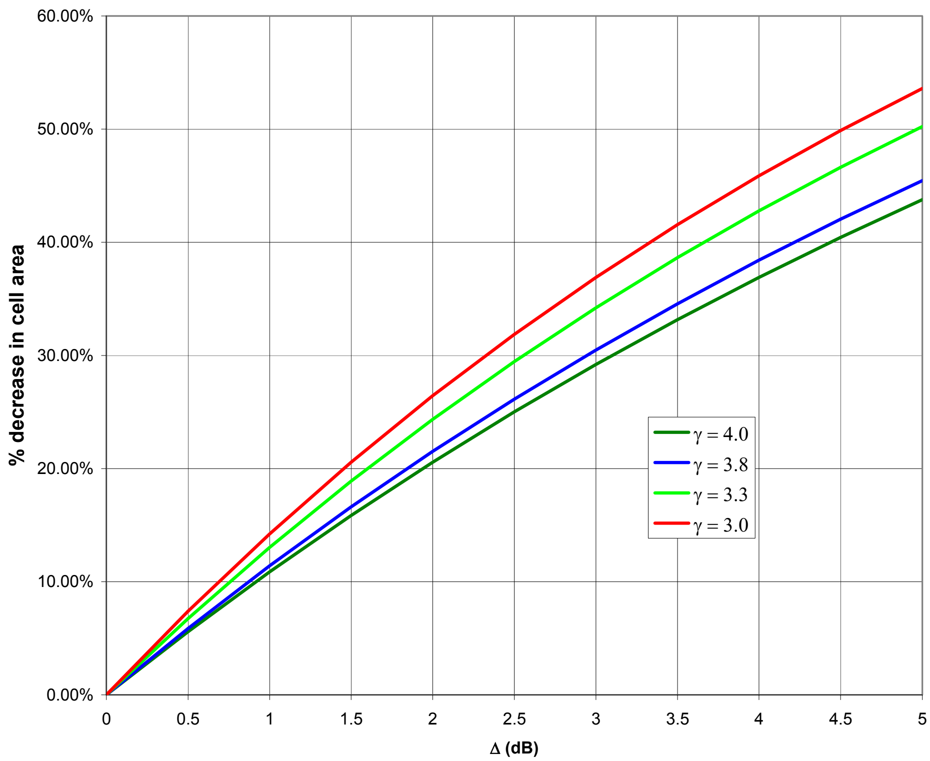

Figure 2: Reduction in coverage area due to □ increase in the *noise temperature*.

This analysis shows that if there is a 1 dB increase in the noise temperature, there would be a 10-15% decrease in the coverage area of CDMA cell sites, depending on the how fast the propagation loss occurs. This decrease is expected to be most pronounced in urban areas, where the carriers are already spending large sums of money to optimize the coverage of their networks. This would constitute a dramatic and intolerable loss of coverage for wireless coverage for American wireless subscribers.

Such an increase in the noise temperature happens to be the level deemed by the Commission not to constitute harmful interference in the UWB and 700 MHz proceedings. <u>See</u> <u>In the Matter of Part 15 of the Commission's Rules Regarding Ultra Wideband Transmission Systems</u>, 18 FCC Rcd 3857, 3886-3887 (2003)<u>; In the Matter of Service Rules</u>

for the 746-764 and 776-794 MHz Bands and Revision of Part 27 Rules, 15 FCC Rcd 476, 515-518 (2000). The Commission's notions of harmful interference are out of kilter with the wireless marketplace. There is no room to increase the noise temperature on the licensed bands on which CDMA is deployed, even at the levels that the Commission deems to be benign.

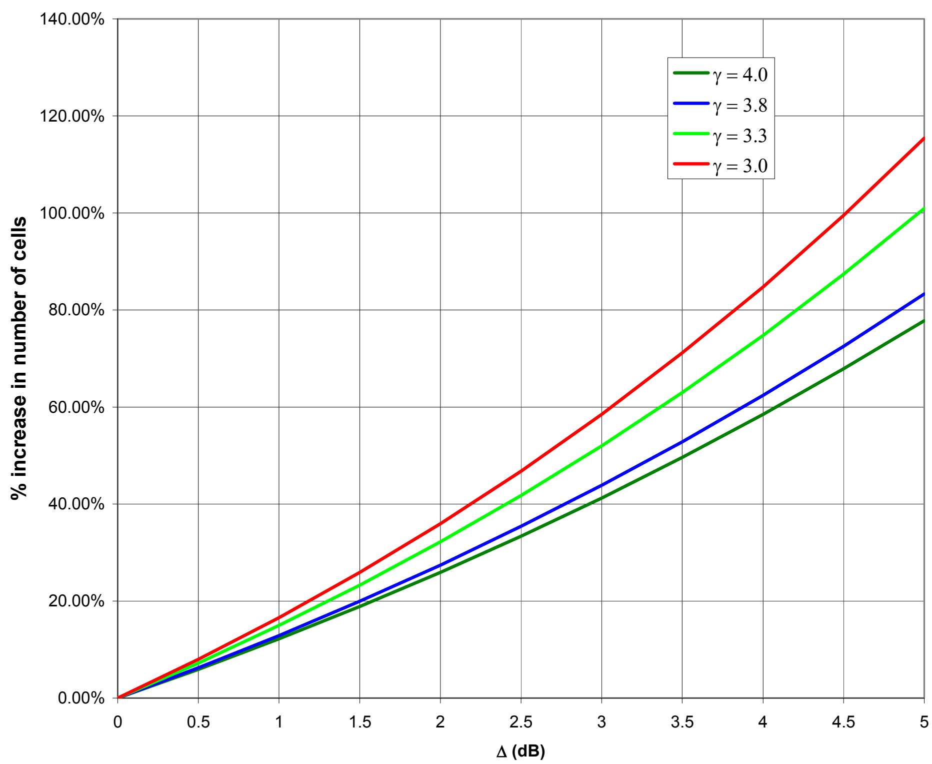

Figure 3: Increase in number of cell sites for □ increase in *noise temperature*.

It is no answer to ask the carriers to add cell sites to cure the substantial loss of coverage. Figure 3 above shows that a carrier would have to add 12-17% more cell sites to maintain its present coverage in the face of a 1dB increase in noise temperature. Such an increase in cell sites would impose tremendous costs, and, in any event, it is quite doubtful that a carry could actually increase its cell sites throughout its network to such a large extent extent. Given local zoning issues and the other difficulties that carriers find in adding cell sites, it is unlikely that an increase of this magnitude in the number of sites could be accomplished. Accordingly, the inescapable conclusion is that if the noise temperature were to increase in the PCS or cellular band, American wireless subscribers would have to endure a much lower quality of service than they enjoy today and/or a significantly more expensive service

B. Effect of Interference Temperature on CDMA Base Stations

We study the effect noise temperature increase on CDMA base stations (BSs). The reverse link (RL) of a CDMA network is designed such that for *every* MT

$$\frac{(1-L)S}{N} = SNR_1 \tag{5}$$

where S is the signal power of the MT received at the BS, L is the loading of the cell, and SNR_1 is chosen to meet the desired quality of service. The RL power control this case, the (effective) number of MTs in the cell is related to the loading algorithm is designed so that all the MT signals arrive at the same power at the BS. In this case, the (effective) number of MTs in the cell is related to the loading by

$$K = \frac{L}{(1-L)\left(S/N\right)}, \text{ which implies that } SNR_1 = \frac{S}{KS+N}. \tag{6}$$

Let I be the interference whose effect we wish to study. The increase in the BS thermal noise floor is again given by Equation (2). To counter this increase in noise floor, the received power of *all* the MTs has to be increased by a factor such that

$$\frac{S}{KS+N} = \frac{\alpha S}{K\alpha S+N+I}, \text{ which implies that } \alpha = \Delta. \tag{7}$$

At the cell edge, the MT is maxed out and the increased power required to counter the external interference is not available. Hence the cell radius reduces by the amount given in

Equation (4) and plotted in Figure 1. The corresponding coverage area reduction is plotted in Figure 2. The corresponding increase in the number of cell sites required to maintain the same coverage area is shown in Figure 3.

Inside the cell, the RL power control stabilizes at a point where the MT is (roughly) transmitting □=□ times more power than the case of no external interference. Hence the battery time of the MT reduces by a factor of □. The percentage reduction in battery time is shown in Figure 4.

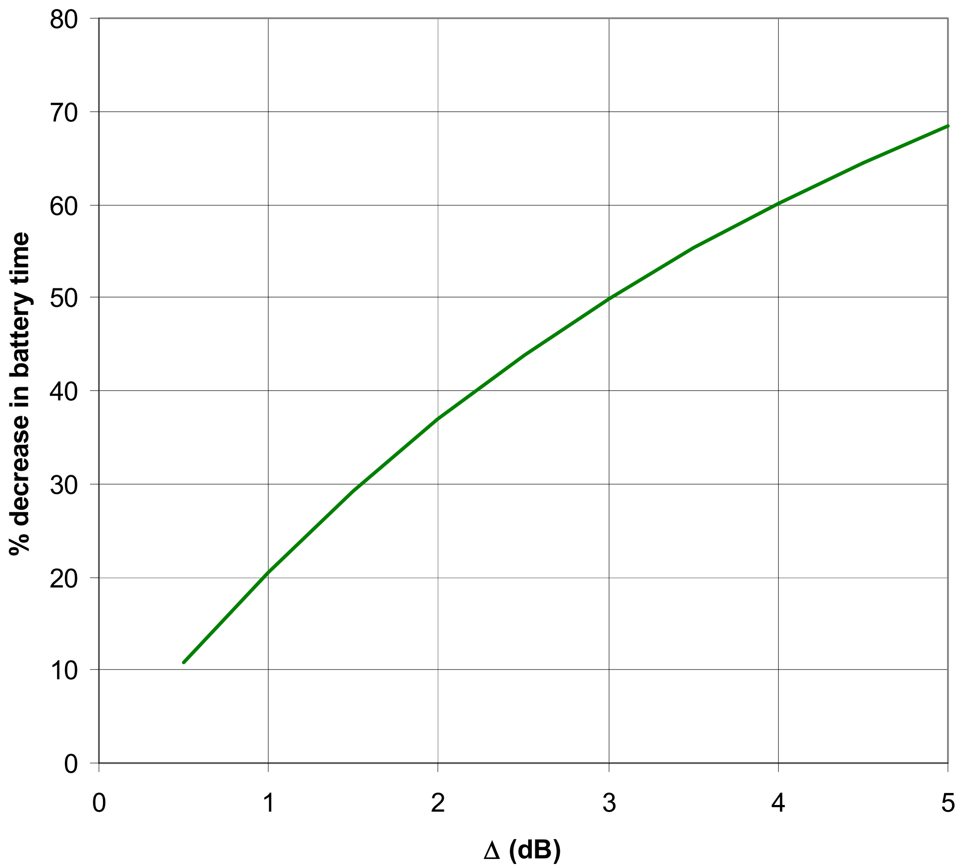

Figure 4: Reduction in battery time of MT due to increase in noise temperature of CDMA BS.

Figure 4, supra, shows that if there is a 1dB increase in noise temperature, CDMA mobile phones would suffer a 20% decrease in battery life. In short, American wireless subscribers would not have the high quality wireless service they enjoy today. The public interest demands that the Commission not permit this result.

In summary, if the thermal noise floor of the BS is increased, then a) the cell size reduces; b) the battery life of a MT is reduced.

C. Effect of Interference Temperature on GPS Enabled Mobile Terminals

Assisted GPS technology, developed by QUALCOMM, enables wireless phones to take measurements from both the GPS satellite system and the terrestrial cellular or PCS network, to transmit the measurements to a server (the so-called Position Determination Entity), which synthesizes the measurements and determines the caller's location with a high degree of precision, and then the location information is automatically transmitted with the call when the caller places a call to 911.

The FCC has required wireless carriers to deploy a position location solution. See 47 C.F.R. Sec. 20.18. Many carriers around the country, including Verizon Wireless, Sprint PCS, ALLTEL, MetroPCS, and Leap Wireless, have deployed Assisted GPS in compliance with the Commission's mandate. These carriers have sold millions of Assisted GPS-capable phones, and many 911 call centers around the country are receiving location information from wireless callers via Assisted GPS.

In a previous submission that QUALCOMM made in the Commission's UWB proceeding, 98-153, on January 11, 2002, QUALCOMM has presented the results of its detailed study of the effect of rise in the thermal noise floor due to ultrawideband devices on PCS phones with Assisted GPS technology for position location. Under the assumptions that UWB interfering signals behave like white noise, the same conclusions regarding the performance of GPS enabled mobile terminals can be extended to other interference sources. The main conclusions of the study are that increase in the noise temperature

1. Decreases GPS satellite availability, hence decrease in position location yield;
2. Decreases position accuracy;
3. Offsets the engineering efforts and large sums of money invested in reduction of GPS receiver NF for in-vehicle and indoor coverage to meet the FCC E911 mandate.

Every one dB increase in the GPS enabled mobile terminals effective interference temperature translates to one dB decrease in sensitivity, and hence a reduction in both the location position yield and positioning accuracy in challenging RF environments.

Given the Commission's longstanding commitment to its E911 mandate and its efforts to enforce the mandate, it would not make any sense to jeopardize the technology on which so many carriers and thus so many millions of Americans are using for E911 service. The public interest lies in supporting, not undermining, the E911 mandate.

III. CDMA Technology Already Ensures That CDMA Networks and Mobiles Operate at the Most Efficient Levels in Terms of Spectrum and Power

The Commission's NOI/NPRM implicitly assumes that the technology deployed on licensed spectrum is inefficient because there is some amount of spectrum that is not used and some amount of additional power which could be emitted into the band. Once again, these assumptions are invalid with respect to a CDMA network. CDMA technology ensures that CDMA networks operate at efficient levels. CDMA networks already achieve the very goals that the Commission is seeking to fulfill through its NOI/NPRM. As a result, there is no reason to impose the interference temperature metric in the bands on which CDMA networks are deployed now, or are likely to be deployed in the future.

A brief review of the inherent efficiency in CDMA networks and mobiles underscores this point. The power control inherent in CDMA networks and mobiles ensures that each mobile always transmits exactly enough power to provide decent call quality, but not more than enough. For example, on the return link, CDMA base stations constantly measure the error rate performance from each mobile transmitting a signal, and, depending on whether the error rate is trending above or below an adequate performance level, the power control circuit is told to ask for a higher or lower signal to noise ratio. A base station function measures the actual signal to noise ratio and compares it to the target, and if the actual ratio is too high or too low, an "up power" or "down power" command is sent to the mobile, which responds by increasing or decreasing its power by approximately 1 dB. All of this occurs approximately 1,000 times per second at each base station and for each operating mobile.

Moreover, the mobile continuously measures the received signal level of the base station signal, averaged over a relatively long time interval, but with a very large dynamic range (about 80 dB). These measurements are used to set the mobile transmit power at approximately the optimal level over this very large dynamic range. The base station commands have a much smaller range, but are transmitted much faster.

These power control features are built into IS-95, 1xRTT, 1xEV-DO, and WCDMA-based networks. All the various flavors of CDMA are based on this inherently efficient design.

In addition to this efficiency achieved through power control, CDMA mobiles have variable rate vocoders which vary the data rate over an 8 to 1 range since lower power can be used for lower data rates. The variable rate vocoder permits the mobile to automatically adjust the power on a frame by frame basis (20 milliseconds) in accordance with the varying data rate.

CDMA networks use a soft handoff process between base stations such that the relative strength of nearby base stations is continuously monitored. Although all base stations communicating with a mobile attempt to control the mobile's power, the mobile pays attention to only to the base station asking for the lowest power. CDMA uses very powerful forward error correction coding and very efficient modulation and implementation so that the necessary signal to noise ratios are very low- approaching Shannon limits.

Indeed, the CDMA technology employed in cellular and PCS systems is extremely efficient in its recovery of useful information from the signals transmitted to an unprecedented extent. This is achieved through a combination of near theoretic performance of modulation and demodulation circuits, as well as aforementioned powerful forward error correction coding and transmitter power control that is fast, wide dynamic range and accurate, and soft handoff techniques that ensure that the mobile is always using the best available base station.

All of these features establish that CDMA networks and mobiles already operate at the most efficient levels. As a result, there is no reason to adopt a new interference metric on the bands at which CDMA networks and mobiles operate because they are already at the optimal levels. It would be unfair and counter-productive for the Commission to force the ultra-efficient CDMA networks to bear any additional interference burden from other system interference, especially given that such other systems are, overall, significantly less efficient than CDMA networks.

To the extent that the Commission wants to promote greater unlicensed operations on additional spectrum over and above the 255 MHz of dedicated spectrum in the 5 GHz band and the 3 GHz of unlicensed spectrum at 92-95 GHz that the Commission recently allocated for unlicensed operations, QUALCOMM believes that the Commission should continue to identify spectrum bands for dedicated unlicensed spectrum, just as it should continue to identify bands for additional dedicated licensed spectrum in light of the dramatic expansion of licensed wireless services. Adopting an interference temperature metric to put unlicensed operations on top of or underneath licensed wireless services is not a viable solution.

Indeed, in evaluating any possible increase in the noise floor in a licensed band on which CDMA has been or is likely to be deployed, it is important to bear in mind the noise figures of CDMA base stations and mobiles. The CDMA2000 standard requires a mobile to have a noise figure of below 9 dB and allows the operator to choose the noise figure of their base stations. In practice, operators require mobiles to have noise figures of 4 dB or lower, and base station noise figures are typically at about 4 dB and often go below 1 dB when superconducting receivers are used as is the case with larger cells. These noise figures are not all the same, making it complicated, if not impossible, for an unlicensed transmitter to determine the susceptibility of each particular CDMA mobile or base station to noise.

Moreover, in weighing the impact of allowing additional noise into a band on which a CDMA network is deployed, the Commission should bear in mind that pseudo-noise waveforms which appear to non-system users as thermal noise. This does not mean in any way that other system noise is benign to a CDMA system. It is certainly not. CDMA intra-system noise all carries useful, revenue bearing information. By contrast, other system noise within the band on which a CDMA network operates does not carry revenue bearing information and instead reduces the capacity of the CDMA network to carry useful information.

IV. The Commission's Proposals for Monitoring Interference Temperature Are Complicated, Vulnerable, and Expensive

The FCC's NOI/NPRM proposes four methods for controlling the operation of unlicensed transmissions. With the exception of one of the approaches, which involves no active monitoring or control of unlicensed transmission, the proposed interference temperature methods invoke a number of complicated, expensive, and vulnerable processes to be developed, deployed and managed. QUALCOMM believes that these approaches are seriously flawed. These flaws are most clearly demonstrated in the Commission's proposals for the imposition of interference temperature in the NPRM portion of the NOI/NPRM, which proposes use of the new metric in the 6525-6700 MHz and 12.75-13.25 GHz bands. The primary services on these bands include fixed service ("FS") links and fixed satellite services ("FSS") uplinks.

Below, QUALCOMM discusses the difficulties and complexities which would result from the various approaches to the interference temperature concept as proposed in the NPRM for the bands used by FS links and FSS uplinks. In this discussion, we use the following acronyms: ULTx: Unlicensed Transmitter; ULRx: Unlicensed Receiver; LTx: Licensed Transmitter; LRx: Licensed Receiver.

A. The Commission's Four "Interference Temperature" Methods

There are four methods for interference temperature analysis considered in the FCC NOI/NPRM. These are referred to in this analysis as:

1) Delta T/T,
2) Self-sensing by the ULTx,
3) Monitoring by LRx,
4) Monitoring by a separate monitoring network.

The "Delta T/T" method simply assumes that some level of interference from low power ULTx will not affect performance of licensed band users. The FCC suggests that a 5% increase to the noise temperature of a typical LRx will not affect capacity or performance of the licensed users. The 5% level is based on ITU guidelines currently used to determine the level of interference from other licensed transmitters that would require co-ordination with a given licensed system due to possible performance degradation. This number is subject to review and change.

With the "ULTx Self-Sensing" method, the ULTx would listen on the frequency channel on which it intends to transmit before actually transmitting and would not transmit if there is a sensed signal above a certain level on that frequency channel.

Under the "LRx Monitoring" method, the level of interfering power as sensed at the LRx is monitored. When interference measured at the LRx rises above a threshold, a control method is used to broadcast a message commanding ULTx units that are contributing to the interference of that LRx to lower transmit power or cease transmissions in that frequency (possibly by switching to another frequency channel).

Finally, the FCC posits a "Separate Monitoring Network" method, which would involve construction of a network of interference level monitors independent of the licensed or unlicensed users. When interference energy measured by the monitoring network in an area rises above a threshold, the network would command ULTx to cease transmissions, to lower power, or to switch to another channel.

B. Considerations for Applying Each Interference Temperature Method to FSS Services

1. Overview

The section discusses impacts on the operation and performance of fixed satellite services (FSS) if each of the four interference temperature methods is implemented with these services. The FSS service currently involves several satellite systems. These satellites generally have footprint visibility to all or most of CONUS and, thus, interference to the LRx located on the satellites comes from the aggregate of ULTx throughout CONUS.

2. Issues with Use of Delta T/T Techniques with FSS uplinks

Many FSS satellites use the same frequencies for uplinks, depending on the directionality of uplink ground-based antennas to reduce interference from orbitally neighboring satellites. However, because ULTx antennas are generally omnidirectional, most or all of the satellite-based LRx in a given FSS frequency channel will receive interference from unlicensed users in that channel. Different licensed satellite systems will have different levels of link budget margin that will tolerate more or less total interference temperature rise before affecting that system's performance. Thus, because the ULTx transmitters cause interference to most or all of the in-orbit LRx receivers operating on a given channel, the licensed satellite with the least margin will have to be used to determine appropriate levels of acceptable unlicensed interference.

The FCC NOI/NPRM suggests that total interference from ULTx at or below 5% of the existing licensed network receiver noise floor temperature is probably acceptable because this is the level that the ITU uses for requiring co-ordination between licensed FSS systems when the interference between systems rises to this level. However, if interference from ULTx rises to a level of 5% of the LRx noise floor, then the threshold for requiring co-ordination between FSS licensed satellite operation due to interference will need to be adjusted to a lower level since the combined interference from ULTx and from other FSS transmissions may then cause performance impacts.

Therefore, uncontrolled ULTx transmissions in the FSS band have the potential to adversely affect the licensed user performance, even if the total allowed interference is limited to a seemingly low level such as 5% of the existing noise temperature. Thus, use of the Delta T/T technique would not simply squeeze unlicensed devices into white space on the FSS band. Instead, this approach jeopardizes the performance of the licensed users on the FSS band.

3. Issues with Use of Self-Sensing Techniques with FSS uplinks

Transmissions from FSS LTx (i.e., satellite ground stations) are highly directional and typically originate from relatively few uplinks. However, due to the generally omnidirectional transmissions from ULTx, interference from ULTx anywhere in the footprint of the LRx will contribute to the total interference at LRx. Any given ULTx will not be able to measure any signal of value to determine if it can transmit since it will not be able to sense the combined interference that the LRx receives from all the ULTx in its footprint. Therefore, this method cannot be used effectively for the FSS band.

4. Issues with Use of LRx Monitoring with FSS uplinks

This concept requires several processes to be implemented in order to monitor interference from ULTx and to control the transmissions from the ULTx. These processes include:

1) Monitoring of the interference temperature at the LRx (on the satellite),
2) The interference level sensed by the LRx must be reported back to the ground,
3) A decision must be made to control the ULTx operation on a given channel, and
4) The control of ULTx must be sent to all ULTx and acted on by these.

a. Process Steps

1. Monitoring

In order to properly monitor the interference from ULTx, all LRx on all satellites in the affected bands will need to monitor C/I+N as sensed at the LRx input. This is a new requirement that necessitates that all satellites be replaced with ones with this capability. Some satellites are simple “bent-pipe” transponders that do no on-board processing or monitoring currently and do not have the ability to monitor C/N+I without significant additional functionality being added. It could require 15 years or more to replace the current in-orbit satellites as they are retired at the end of their life and this method of interference temperature control cannot be accurately used until all affected satellites have the ability to accurately measure the interference received from ULTx.

In addition, accurate methods will have to be developed to allow monitors on LRx to discriminate between noise and interference sources. It is not enough to just measure a rise in the noise floor temperature because noise can be caused by several sources, including atmospheric and extra-terrestrial sources as well as aging on-board components. It is essential that the noise temperature monitor be able to accurately measure interference caused by intentional transmissions from potentially millions of ULTx units operating on the same frequencies. This is not achievable in 2004.

2. Reporting

Once a measurement of interference levels is made on the satellite, a means must be provided for reporting measured interference levels back to ground. Many satellites already have an existing control channel that can be used to relay this information to the ground, but the capability to transmit interference level information would have to become an absolute requirement for all future communication satellites in this band before the Commission could impose this approach to interference temperature.

3. Determining response

A control network will have to be established to monitor interference information relayed from all satellites in the band in which ULTx are operating and a determination will have to be made when a threshold has been exceeded and what action to take on the part of the ULTx. This is a completely new system that will have to be developed and implemented. Such a system will need to be very carefully designed and maintained as it will be a critical single point of failure affecting the performance of all unlicensed and licensed services in the band. There is no such system today.

b. Distributing response to unlicensed users

A means for communicating transmission control commands from the control system to all ULTx in the affected band is necessary. All ULTx will have to be designed with the ability to receive the signal that commands it to cease transmissions, reduce Tx power or switch to new channel. This necessitates that all ULTx units must have a receive capability and in a different frequency than that of its transmissions so that commands can be received while it is transmitting. Alternatively, the ULTx will need to operate in some form of half-duplex mode so that it can cease transmissions and listen for commands from the control network. This prevents operation of "transmit-only" unlicensed products which may add significant cost and may not even be practical to some ULTx units. A nationwide coverage wireless broadcast capability will also need to be developed with the ability to transmit commands to all ULTx units at any time. This broadcast signal will need to be able to communicate commands regarding the authorization to transmit by ULTx for many different channels. The ULTx will need to receive and interpret the command that is specific to its desired transmission channel.

Again, these capabilities do not exist today.

c. ULTx response

Every ULTx will be required to have a dynamic means to reduce or cease transmissions when so commanded. This will probably require that the ULTx implement either Transmit Power Control (TPC) or Dynamic Frequency Selection (DFS) capabilities adding further complexity and cost to the ULTx devices. Alternatively, the command to reduce interference on a particular channel could just "turn off" all ULTx on a nationwide basis or implement some kind of co-ordination of ULTx so that some units turn off while others don't.

5. Complexity and Cost Impacts

The LRx Monitoring method adds significant complexity and cost to every system element involved, both the licensed and unlicensed equipment as described in this section.

a. LRx

The LRx on the satellites will be required to have a means for monitoring interference and communicating interference information back to ground which is a significant new requirement, especially impacting otherwise unsophisticated satellite transponders.

b. ULTx

Typical unlicensed products are generally low-cost. However, the use of interference temperature methods to authorize transmissions by ULTx requires additional complexity and, potentially, high cost addition to the ULTx. The ULTx must have a means to receive commands to cease or reduce transmission. This probably requires full-duplex operation in ULTx and the ability to receive, demodulate and parse transmission authorization commands as well as requiring the built-in capability for TPC or DFS.

c. Command and Control Network

A new nationwide command/control network will need to be developed and implemented to gather interference level information from all satellite systems, determine ULTx control commands, and broadcast ULTx control commands with nationwide coverage. This is a critical network component and will need to be implemented with very high reliability and closely maintained.

While the assumption here is that the geographic area of interest is primarily CONUS, the actual coverage of the control network transmission will be anywhere that the interference temperature methods are applied to the FSS service coverage area.

C. <u>Other Considerations</u>

In addition to the considerations given above, there are a number of additional considerations regarding the use of interference temperature as a means for controlling the interference from ULTx to LRx.

D. <u>Security of the Interference Management Process</u>

One simple high-powered jammer could cause a LRx on a satellite to sense too much received interference resulting in a shut-down command to all ULTx operating on a specific channel in the entire country. This is a significant and untenable vulnerability to the nationwide population of ULTx.

Also, the network that aggregates the interference information from the FSS systems and authorizes the transmission of the ULTx must be quite robust and secure. If that network fails, either all the ULTx units in the country must default to cease transmissions or the interference to licensed FSS systems could be adversely affected. QUALCOMM believes that this vulnerability is not acceptable.

1. <u>Response Time May Be Too Slow</u>

This closed-loop control method depends on a fast response when interference levels rises too high. Periods of satellite performance degradation are possible until a condition of high levels of interference is reported and interfering ULTx shut-down, reduce transmit power, or change channels.

2. Satellite Transponder Vulnerability

A failure on any licensed satellite transponder that causes an incorrect sensing of interference levels could result in all unlicensed users in the entire country using that channel to be commanded to cease transmission.

E. Issues with Use of New Monitoring Network with FSS uplinks

Without even considering the complexity, practicality, or cost of establishing a nationwide monitoring network, it is important to realize that such a system cannot be made to work with the FSS service. This is because, just as with the "ULTx Self-sensing" approach, it is not possible for a terrestrial monitoring network to accurately determine the interference levels that would be present at the LRx on the satellites due to directional attenuation and the distribution of ULTx across the entire CONUS. This approach is just not realizable for FSS bands.

F. Considerations for Applying Each Interference Temperature Method to FS Services

Applying interference temperature methods to control ULTx operation in the terrestrial fixed services (FS) band poses issues very similar to those discussed above for the FSS services. The following gives a brief discussion of applying these techniques to FS services.

1. Issues with Use of DeltaT/T Techniques with FS services

With a terrestrial FS service the "near-far" issue with interfering ULTx units is much more pronounced than with the FSS service. That is, ULTx devices located near an LRx unit will contribute high levels of interference temperature increase while ULTx equipment located further away from the LRx will have less of an interference impact. It will be necessary to set the allowed ULTx transmission to a low level in order to prevent ULTx units located close to the LRx from causing unacceptable interference greatly limiting the ULTx available capacity.

2. Issues with Use of Self-Sensing Techniques with FS services

The concept here is that an ULTx unit will listen to the channel on which it intends to transmit and if the received RF energy exceeds a threshold level, the ULTx will not be authorized to transmit. However, the ULTx will not be able to tell the difference between its sensing of a licensed or an unlicensed transmission and will not be able to make an accurate decision whether or not to transmit. This could be handled by having all ULTx units cease transmissions at the same time for a short period, but this requires very accurate time synchronization between the ULTx units.

3. Issues with Use of LRx Monitoring with FS services

The issues with LRx monitoring of the interference levels are similar to those discussed for the FSS services. It is difficult and costly for the LRx to monitor interference and to discriminate the sources of interference. In addition, the problem of commanding only those ULTx units within range of the LRx requires some method for determining which ULTx are affecting the interference to a specific LRx.

4. Issues with Use of New Monitoring Network with FS services

The issues with this method are again similar to those discussed above for the FSS services.

G. Summary of Impact of Interference Temperature Methods Applied to FS Services

In summary, just as with the licensed FSS band, any of the proposed methods for applying interference temperature methods for management of ULTx operation in a licensed FS band will result in very significant costs and complexity to both the licensed and unlicensed equipment. In addition, the security and reliability concerns addressed in the FSS service discussion above apply to the FS band, as well. For all of these reasons, QUALCOMM does not believe that the interference temperature metric should be applied to any of the licensed frequency bands.

VI. Conclusion

Wherefore, for the foregoing reasons, QUALCOMM respectfully requests that the Commission not impose the interference temperature metric in any of the licensed frequency bands.

Respectfully submitted,

By: /s/Dean R. Brenner

Dean R. Brenner
Senior Director, Government Affairs
QUALCOMM Incorporated
2001 Pennsylvania Ave., N.W.
Suite 650
Washington, D.C. 20006
(202) 263-0020
Attorney for QUALCOMM Incorporated

Dated: April 5, 2004